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Italy-Vietnam Scientific Cooperation in the field of GNSS

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Abstract—Scientific collaboration between Italian and Vietnamese institutions in the field of Global Satellite Navigation Systems (GNSS) dates back to 2004, when a first train-the-trainer action was conducted in the Hanoi University of Science and Technology (HUST) by researchers of Politecnico di Torino and Istituto Superiore Mario Boella (ISMB). In the following years, a closer and tighter collaboration between these institutions has allowed for the setup of a Collaboration Centre on GNSS in HUST, the NAVIS Centre. After more than a decade of collaboration, the NAVIS Centre has become a key reference point in the area for European and Italian institutions and companies active in the field of GNSS. The paper describes the activities and projects that have allowed the set up and growth of the Centre as well as the achieved results and future perspectives.

Keywords— International Cooperation; Satellite Navigation; Galileo System; Second Level Specialising Master;

I. INTRODUCTION

The European Union (EU) decided to develop its own Global Navigation Satellite System (GNSS) in the nineties of the past century. At that time, the US-owned system GPS and the Russian system GLONASS where the only two available GNSS, mainly developed for military purposes. However, GPS was providing also freely accessible signals, although with degraded performances. Leveraging the global availability of these GPS signals, different location based services and other GNSS based applications were developed. New services and solutions were appearing in different fields of application, clearly showing that GNSS was a great enabling technology facilitating sustainable economic and social development. GPS based services and solutions were still in an early development stage, nonetheless they clearly showed the tremendous potential of this new cross-cutting technology whose importance started to be clearly perceived.

In 1999, a EU Council Resolution, while recognizing satellite navigation as a key technology for EU, stated the need to start developing the independent European GNSS Galileo [1], primarily

intended for civilian use. Since then, the European Commission (EC) has been funding research activities focused on satellite navigation technology, with several actions in different fields in order to develop and strengthen European technological capabilities in this strategic domain.
Besides building and deploying the system, EC has also been actively promoting the adoption of Galileo in different fields of applications stressing its primary civilian nature. For this reason, the EU encouraged International Scientific Cooperation assigning funds through the Framework Programme for Research and Technological Development. Starting from the Seventh Framework Programme (FP7), international activities actions in some areas of the world have been funded. Politecnico di Torino and Istituto Superiore Mario Boella (ISMB) identified South East Asia (SEA), and Vietnam in particular, as one of the most interesting regions in the world. The reason for this is twofold. Firstly, there are socio-political considerations motivating the interest for South East Asia. It is a fast-changing region with countries experiencing different levels of development and very diverse outlooks. Nonetheless, all of them are developing quite fast and have a keen attention to logistics and infrastructures, which are key elements to support industrialization and sustainable social and economic growth. The related steadily increasing demand for better services and logistics in the region is continuously requiring more and more solutions which make use of GNSS based applications. In addition, South East Asia is experiencing the multi-GNSS environment at its edge being covered by all the global and regional systems: GPS (US), Galileo (Europe), GLONASS (Russia), BeiDou (China), QZSS (Japan), IRNSS-NAVIC (India). This makes South East Asia one of the most challenging areas of the world: it is an important GNSS market, but it has not its own GNSS. Consequently, GNSS providers, are struggling to get a share of that market. Gaining recognition and interest in this area is therefore a key factor to gain important GNSS market shares. South East Asia can be identified with the ASEAN (Association of Southeast Asian Nations): Indonesia, Malaysia, The Philippines, Singapore, Thailand, Brunei Darussalam, Viet Nam, Lao PDR, Myanmar, Cambodia. Among them, Vietnam is of consistent interest since it is one of the largest ASEAN Member States, in terms of population, with a fast-growing economy that is attracting interest from all over the world.

The second reason of interest for Vietnam and South-East Asia is more technical. The multi-GNSS environment experienced there makes it an ideal location for tests and trials of equipment and applications designed for the global market. On top of this, the geographical location of Vietnam (and Hanoi in particular) close to the magnetic equator is of great interest in connection with the study of the ionosphere and of its anomalies that affect the performances and the precision of GNSS based PVT (Position, Velocity, Time) determination.

II. ITALY-VIETNAM JOINT ACTIVITIES IN THE FIELD OF GNSS

In this framework, Politecnico di Torino and ISMB, a non-for-profit research institute active in the field of Information and Communication Technologies based in Torino, Italy, started their activities in Vietnam in the field of GNSS in 2004, soon after the EC and the European Space Agency (ESA) completed the first design phase of Galileo.

A. The starting point

Everything started with JEAGAL-*Joint European Asian educational and application development programme on GALileo*, a project funded by the Asia IT&C program of the EC. JEAGAL was a train-the-trainer project that brought Italian and Spanish researchers in Vietnam and China to conduct awareness activities on European GNSS technologies. In addition, it supported Vietnamese and Chinese students to attend the Second Level Specializing Master on Navigation and Related Applications at Politecnico di Torino. Some of the Vietnamese students were then selected for enrolling into the PhD Program in Telecommunication, which allowed them to deepen their knowledge in GNSS receiver technology.

B. Setting and Growing the Centre

The cooperation with the Hanoi University of Science and Technology had a further boost thanks to an initiative of the European Commission which supported the set-up of a Collaboration

Centre on GNSS in Vietnam, the NAVIS Centre, which started its operations in October 2010 [2]. In parallel, with the support of an Italian-Vietnamese bilateral project, ancillary actions to increase the technical cooperation between Italian and Vietnamese researchers were undertaken. Besides supporting some exchange visits of researchers to facilitate joint research, a competition was organized soliciting small groups of Vietnamese students leaded by one professor to propose innovative application of GNSS.

After its opening, the NAVIS Centre started working to achieve its mission, i.e. to ease cross-links between EU and SEA actors, to promote European GNSS technology and to reinforce international collaboration in the field of GNSS. The FP7-funded project *Growing NAVIS* [3] supported the growth of the NAVIS enhancing its technical and research capabilities and extending its links in SEA and in Europe. During the project, Vietnamese students and researchers had the opportunity to spend study and research periods in Italian universities and research centers. This allowed them to establish long-term links with European researchers and to get used to the European environment. On the other hand, Italian researchers had the opportunity to visit Vietnam and to conduct joint research activities on topics related to algorithms for GNSS receivers.

C. *A Step Forward: GNSS-based Ionospheric Monitoring*

New opportunities of scientific collaboration between Italy and Vietnam appeared when ESA promoted a series of studies to better understand the behaviour of ionosphere at low latitudes. Being Hanoi located under the Northern Crest of the Equatorial Ionospheric Anomaly, the NAVIS Centre became the natural partner for a measurement campaign which lasted six months. The data collected during this campaign were analysed to better characterize the effects of ionospheric disturbances on GNSS signals. These studies, namely *GINESTRA*, *ERICA* and *IBISCO*, have been conducted also in collaboration with the Italian National Institute of Geophysics and Volcanology (INGV), based in Rome [4] [5]. An example of the outcomes of these studies is shown in Fig. 1**:** a map (sky plot) of scintillation activity on local sky. This map was derived by GNSS measurements obtained with a receiver installed at the NAVIS Centre. This map makes it possible to easily identify the portions of sky above the receiver where scintillation events occur.

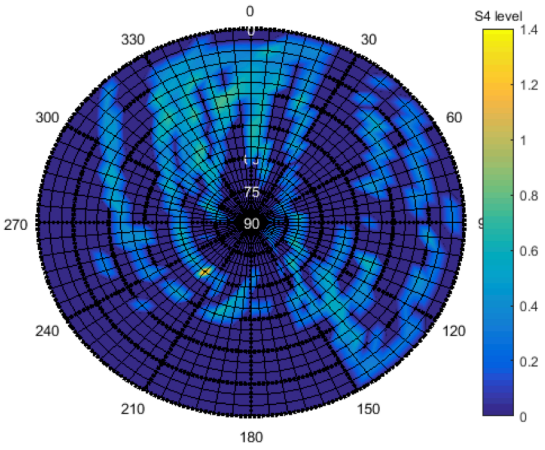

Fig. 1: Map of scintillation disturbances in local Hanoi sky (amplitude). Tool developed within the ERICA study.

D. *Support to Companies*

The last step of the collaboration between Italy and Vietnam has been accomplished in the framework of an H2020-funded project leaded by ISMB: *BELS* [6] [7]. With this action the collaboration between Italy and Vietnam has been widened still addressing research, training and awareness in the field of GNSS technology, but aiming also at supporting RTD and business needs of European industries and companies operating in the GNSS sector. This task is accomplished offering companies the possibility to visit the NAVIS Centre and conduct tests and experiments in the challenging multi-GNSS environment available in Hanoi (and not in Europe) which also suffers of the problems related to anomalies of the ionosphere that are typical of low latitude regions. Experienced NAVIS staff can provide expert support to experiments and can also facilitate contacts with local authorities and stakeholders potentially interested in business deals with the European

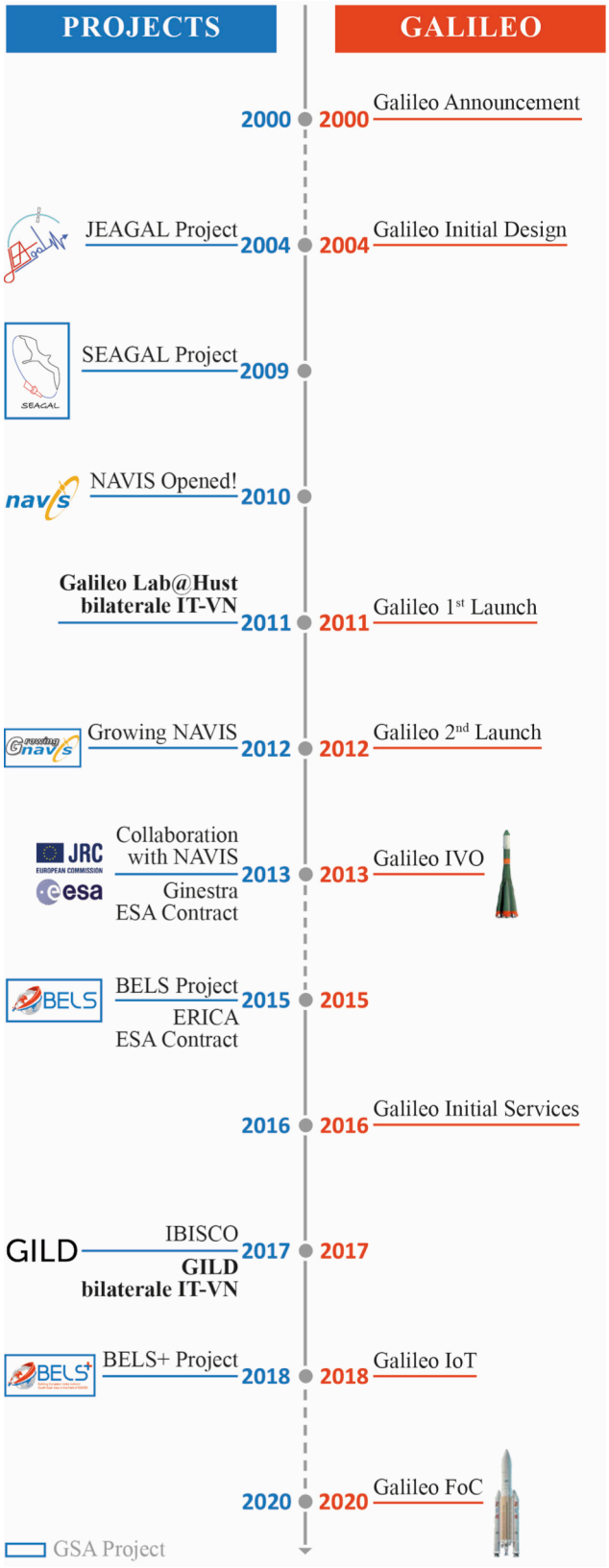

Fig. 2: Timeline of the joint activities in the field of GNSS conducted by Politecnico di Torino, ISMB and the NAVIS Centre of the Hanoi University of Science and Technology (left) and of the Galileo system development (right)

visitors. Through these actions the NAVIS Centre has really become the hub for European GNSS stakeholders interested in exploring SEA and the opportunities that the region offers in the field of GNSS.

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A pictorial overview of the joint activities in the field of GNSS conducted by Politecnico di Torino, ISMB and the NAVIS Centre of the Hanoi University of Science and Technology is given in Fig.2

III. NAVIS Promotion Policy at Home and Abroad

In 2011, for the NAVIS Centre, the President of HUST strongly supported a policy with strong international connections. While signing a specific cooperation agreement with Politecnico di Torino concerning the joint activities of the Centre in the field of satellite navigation, he also reshaped its top management appointing a Vietnamese Director and an Italian Co-Director. With this move the collaboration between HUST on the one side and Politecnico di Torino and ISMB on the other side became tighter and more continuous and facilitated the execution of the different actions already described in Section II. Considering the important links of the Centre and its staff with Italian and European institutions and taking into account that the Centre was setup with consistent support of European funds to facilitate links between Europe and South-East Asia, it is obvious that a consistent share of the international activities of the Centre have been focused on Europe. Besides working with European universities and research centres, the NAVIS collaborated also with ESA and with the Joint Research Centre of the European Commission based in Ispra (Italy). For both, the NAVIS hosted receivers and equipment and conducted studies and research. The NAVIS has also been one of the first 50 users of the Galileo system in the world, as certified by ESA.

Indeed, since the very beginning the Centre's management devoted keen attention also to relations with other countries in the Asia-Pacific and South-East Asia regions. In this framework, the Centre has been collaborating with the Japan Aerospace Exploration Agency (JAXA) with a variety of actions: by hosting a receiver of its network in support of the QZSS Regional Navigation System, by organizing workshops and seminars in cooperation with different institutions of neighbouring countries, etc. Throughout the years, the regional reputation of the NAVIS has increased. The Centre joined the Multi GNSS Asia (MGA) Association [8] and in 2016 the Centre's director became one of the two chair persons of this association.

Along with the attention for international relations and for international recognition pursued through study and research, the policy of the NAVIS dedicated also careful attention to the development of relations and collaborations with domestic GNSS stakeholders. Actually, the NAVIS started its activity at a time in which in Vietnam the interest for GNSS based services and applications has been consistently surging. The feeling that this technology can provide valuable solutions for tackling social and economic problems allowing better and safer standard of life has been spreading. Different Ministries and public agencies started looking at GNSS based applications as an efficient way to overcome important problems and difficulties. The best example is probably the adoption, by the Ministry of Transportation, of a decision that requires all commercial vehicles (busses, trucks, taxis) to be equipped with black boxes recording speed and position of the vehicle using GNSS technology. Such data, transmitted to the Directorate of Road Administration, allow public authorities to identify law infringements and to distribute penalties. However, if on the one side this approach allowed a consistent reduction of the number of road accidents and consequent casualties, on the other side it likely induced a larger use of jammers operated by those who do not want to be tracked.

In this very dynamic domestic environment, the NAVIS has been having the opportunity to play a crucial role. Its staff have very high qualification in the specific field of GNSS and, thanks to their international links and collaborations, can bring to their country solutions and knowledge which can be hardly found elsewhere. The NAVIS is therefore developing its research and technology transfer actions in connections with those themes that are of large interest for Vietnam and that can bring important benefits.

IV. Latest Activities

Recently, a very hot topic in GNSS research is detection and localization of interfering signal and of jamming and spoofing attacks [9] [10] [11]. In this field, it is focused the project *GILD*, a bilateral Italy-Vietnam project whose goal is to design and implement a prototype for the detection and localization of interfering and jamming signals. The prototype will be implemented on a smartphone so as ease the real-time detection of sources of signals which could impair the proper functioning of GNSS receivers. During the first year of the project, Italian and Vietnamese researchers have worked together to:

- Analyse the state-of-the-art algorithms for interference and spoofing detection and localisation;
- Analyse the characteristics of available hardware components;
- Prepare a high-level design of the prototype;
- Identify the most suited algorithms to be implemented on the target platform.

In addition, a workshop on this topic was organised in Hanoi with the participation of Vietnamese governmental officers, researchers and representatives of private companies. Goal of the workshop was to make them aware of possible threats which could impair the use of GNSS-based services. The workshop was successfully organised in Hanoi in November 2017. It was attended by more than fifty participants and provided them a good picture of GNSS-related activities in Vietnam.

V. Future Work

In the next two years, the collaboration between Italian and Vietnamese researchers and institutions is expected to continue, in particular in the framework of two projects. Activities of the GILD project will continue with the aim to arrive to a first prototype of the interference detector by the end of 2018. Furthermore, European companies working in the field of GNSS will be offered additional opportunities to enter the South-East Asian market thanks the the H2020-funded project BELSPLUS. This project started its activities in March 2018 and will be operative for 24 months. The main outcome of BELSPLUS will be a Demo Centre at the NAVIS where European companies can showcase their EGNSS products and solutions.

VI. Conclusions

The participation of Italian and Vietnamese institutions in many joint activities over more than a decade has allowed Vietnamese young researchers and PhD students to visit Italian universities, research centres and companies. These people are now the key contact point of Italian and European activities in the field of satellite navigation in Vietnam.

In addition, the joint research work conducted by Italian and Vietnamese teams has contributed to the creation of very strong links between team members. This easies the set-up of new activities and projects and paves the way for new opportunities of joint actions.

Acknowledgment

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